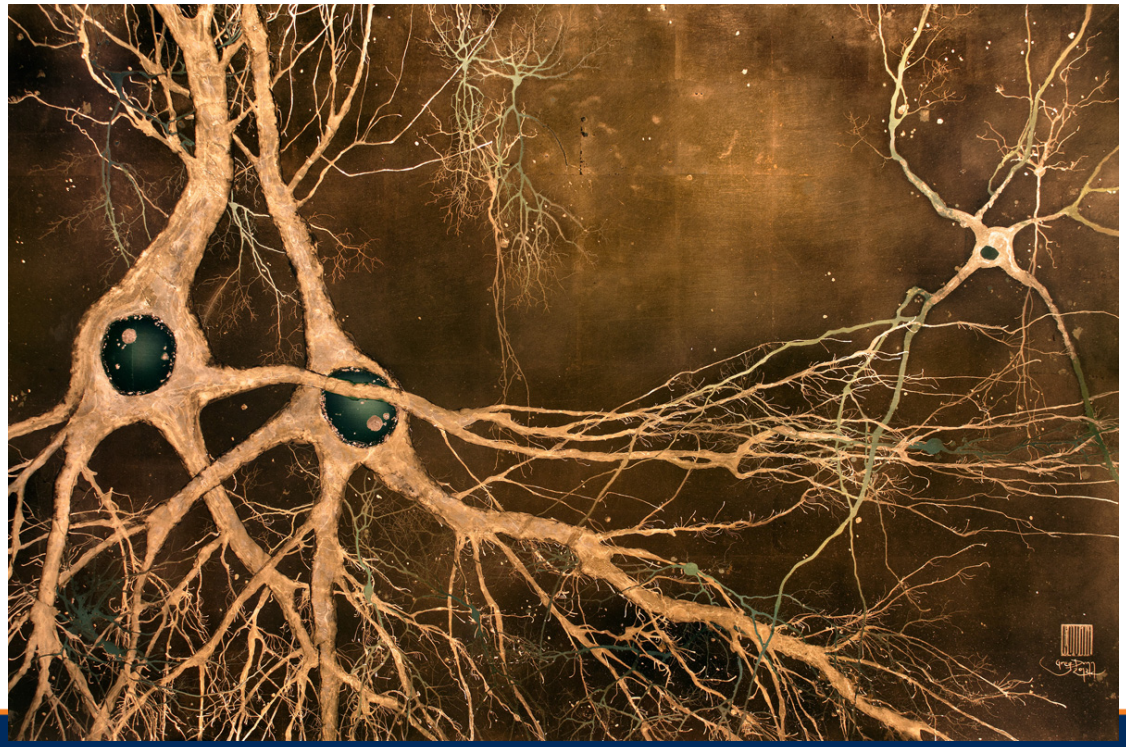
PSYC305: Cognitive Processes

Marcus Cappiello

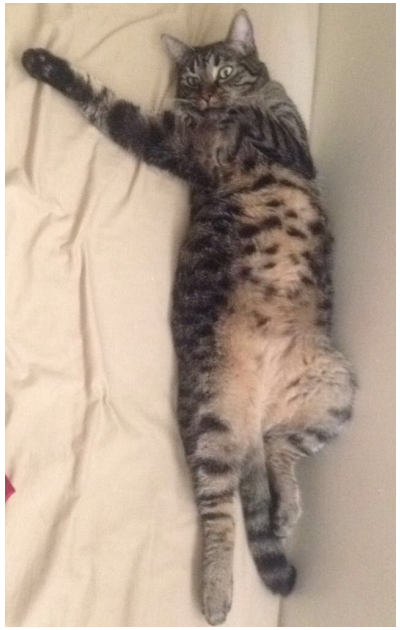


Agenda

- Introductions
- Tips for undergrad & grad school
- Syllabus
  - Course organization
- Intro to cognition
  - Why cognitive neuroscience?
  - History
  - Functional neuroanatomy
  - Methods

Introductions

- Professor: Marcus Cappiello
  - 4th year grad student
- Intermission entertainment: Daisy and Fiddler



Tips for getting into grad school

- GPA and GRE scores only matter to a point
- Most important:
  1. Fit to the lab
     - Show interest in the lab material
     - Why would you be a good addition?
  2. Lab experience
     - Join a lab as soon as possible
  3. Letters of recommendation
     - One for you're lab experience
     - One from a professor (whose class you did well in)

Tips for higher education

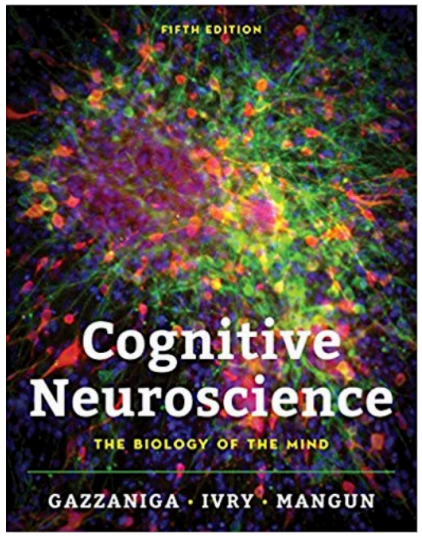
1. Sleep more than you study
2. Study more than you party
3. Party as much as possible

What can you do with cognitive psychology?

- Academia
  - Research professor
  - Teaching professor
- Industry
  - Military
    - Brain enhancement
  - Artificial intelligence
    - Best systems built by modeling the brain
  - Virtual reality
  - User interface research

Course Structure and Layout

- Course will cover a wide variety of cognitive processes, including
  - sensation and perception
  - object and face processing
  - learning and memory
  - knowledge and language
  - attention and consciousness
  - cognitive control
  - social/affective/neuroscience



- "The Biology of the Mind" or how the brain gives rise to our experiences, thoughts and behaviors.

Think, pair, share

- Each lecture there will be at least one TPS
- I will provide a prompt/question
  - Think about it on your own first (no talking)
  - Get together in a small group (min 2 in a group) and discuss what you think
  - Share with the class (included in your participation)

Grading

Midterms	30% (10% each)
Quizzes	10%
Short Papers	15% (5% each)
Final	30%
Term Paper	15%

3 midterms – material from lecture only

1 final – cumulative

3 short papers – link class topic to outside world

1 term paper – summary of empirical study

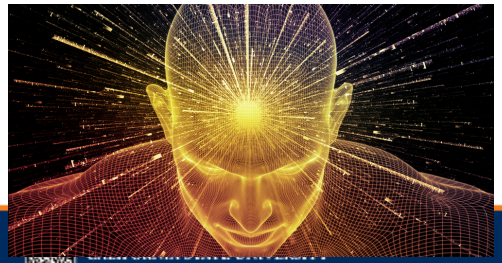
Quizzes

- 6 points total
- Will include attendance/participation (1 pt. for turning it in)
- ~8 questions each quiz
  - Will not have quizzes on review or test days
- First 4 questions will be from previous lecture
  - Multiple choice
  - Will be graded! 2 points total
    - Half or more right – 2 points
    - 1 right - 1 point
- Second 4 questions will be on material covered during the current lecture
  - Will not be graded, only given points on completion (1 point)
  - Gets you to think about the material before you see it

Quiz 1

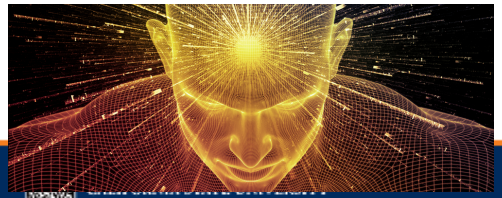
1. What is the goal of cognitive neuroscience as a research field?
2. What is the black box problem?
3. What is phrenology and how does it relate to modern day cognitive science?
4. Name the 4 lobes and where they are in the brain (draw a picture).

Why Cognitive Neuroscience?



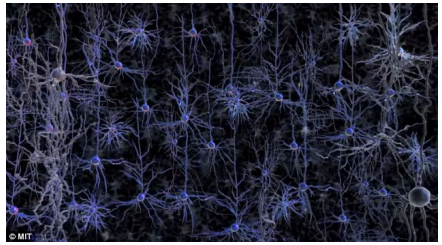
Why Cognitive Neuroscience?

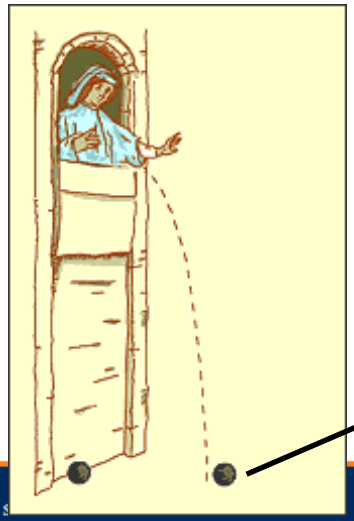
- Politics
- Education
- Art
- Social interactions
- Science
- Philosophy
- *Everything we do*



Cognitive neuroscience: goals

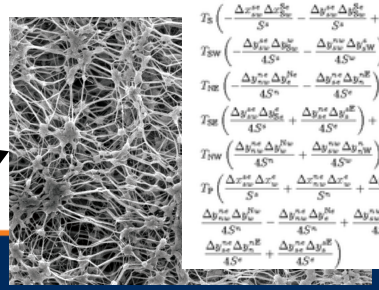
- To understand the brain!
- Model every cell interaction?
  - Then you have a brain again… haven't learned anything new
- Example: physics of a ball dropping

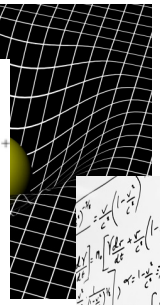




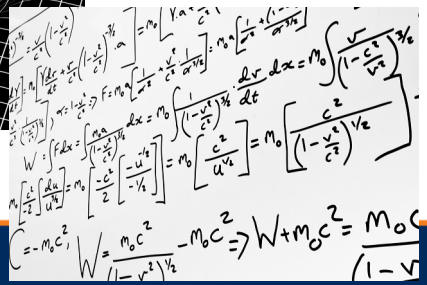
$$\tau + \delta\tau = \int \left(-g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{dx^\nu}{d\lambda} - \partial_\sigma g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{dx^\nu}{d\lambda} \delta x^\sigma - 2 g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{d(\delta x^\nu)}{d\lambda} \right)^{1/2} d\lambda$$

$$= \int \left(-g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{dx^\nu}{d\lambda} \right)^{1/2} \left[1 + \left(-g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{dx^\nu}{d\lambda} \right)^{-1} \times \left(\frac{\partial}{\partial x^\sigma} - \frac{dx^\mu}{d\lambda} \frac{dx^\nu}{d\lambda} \right) \left(-g_{\mu\nu} \frac{dx^\mu}{d\lambda} \frac{d(\delta x^\nu)}{d\lambda} \right) \right]^{1/2}$$





X 10^{50}



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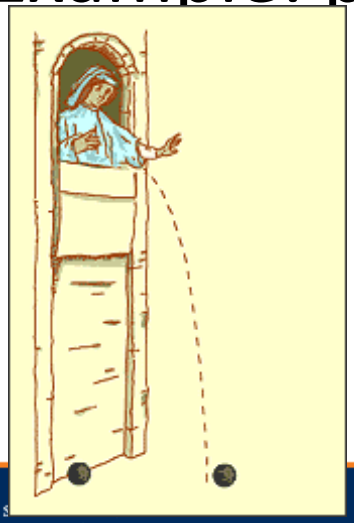


$$y = y_0 + v_0 t + \frac{1}{2} a t^2$$

initial speed

initial position

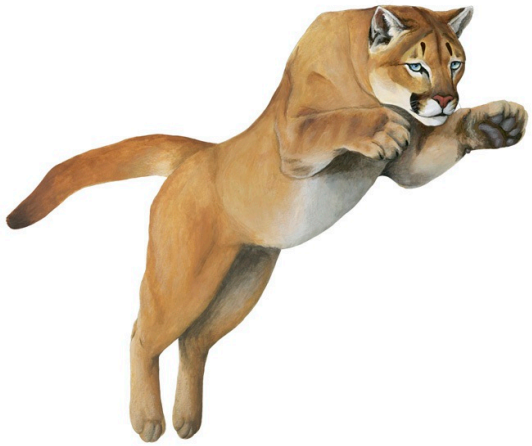
Ball rolling
Two balls being juggled
Two people high fiving
ANY MOVING THING

Cognitive neuroscience: goals

- To understand the brain!
- Model every cell interaction?
  - Then you have a brain again… haven't learned anything new
- Instead, we want to *simplify*
  - Find underlying principles that can be used to describe the brain and cognition

The Black Box Problem

Environment (Observable) → Black Box → Behavior (Observable)



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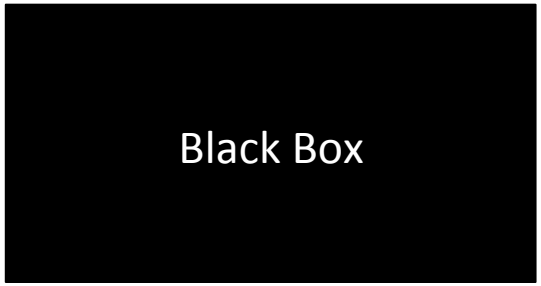

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Cognitive Neuroscience

- Infer what is happening by looking at behavior
  - Behavioral paradigms
- Observe what happens when the box (the brain) is damaged
  - Case studies
- Observe what happens when we mess with the box
  - Brain stimulation
- Can image what is happening inside the box
  - Brain imaging

David Marr's three levels of analysis

- Computational level
  - What does the system do and why
    - Nothing about how
- Algorithm level
  - How does the system do what it does
    - Representations and processes
- Physical level
  - How is the system physically realized

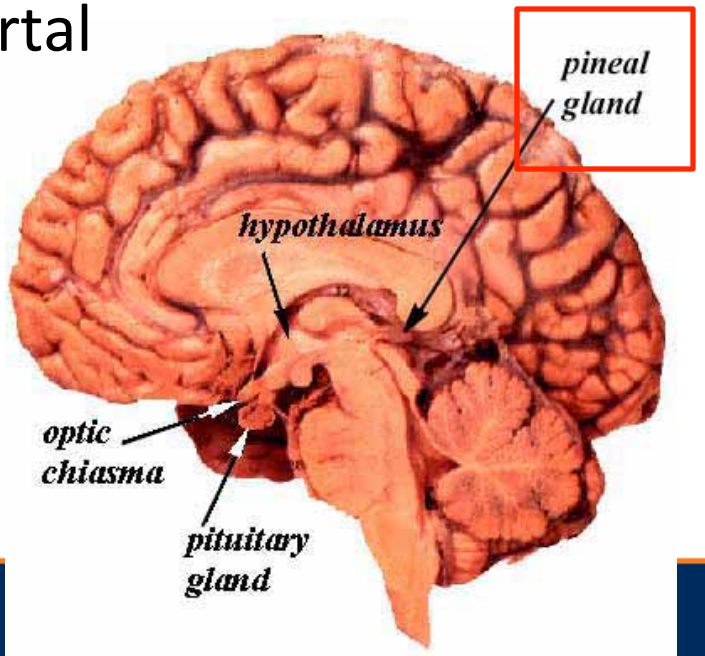
Cognitive neuroscience: Understand all three levels

Think, pair, share

- How is the mind related to the physical brain?
  - Mind: feelings, thoughts, emotions, and conscious awareness

History: How is mind related to the brain?

- Mind-body problem: how can a physical substance give rise to our feelings, thoughts, emotions?
- Dualism - Rene Descartes (1596-1650)
  - Mind was non-physical (awareness) and immortal
  - Brain was physical and mortal
  - Interact in the…



How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

Subjective

Objective

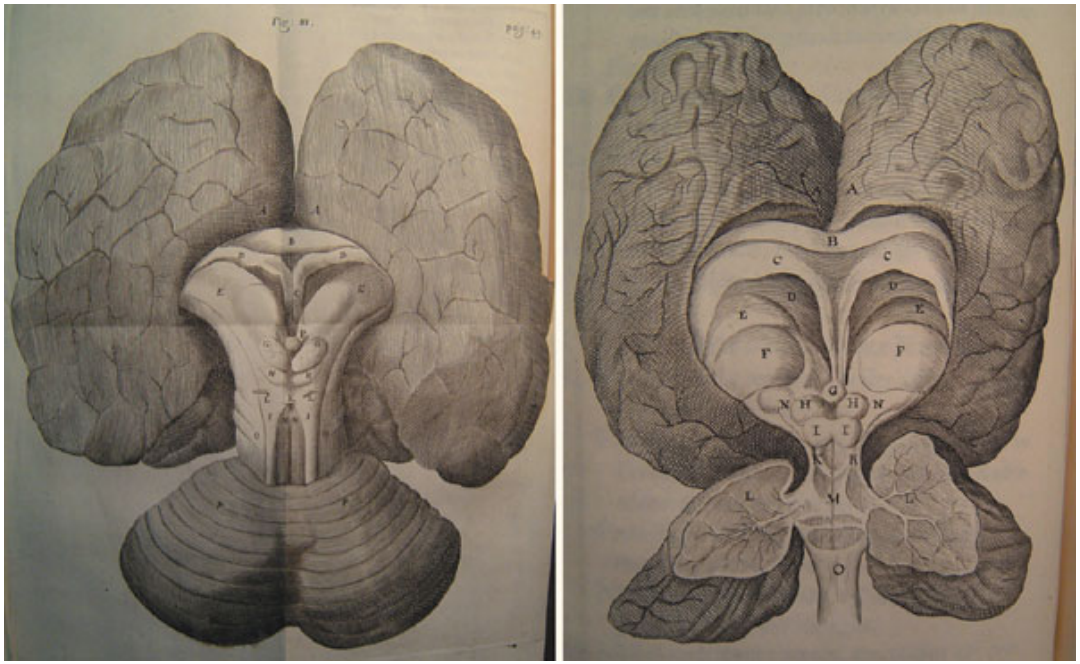
How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

- Reductionism (Churchland, Crick)
  - Mind can be reduced to biological constructs (e.g., patterns of neuronal firing, neurotransmitters)
  - "there is no soul, no mind, only the brain"
  - Only objective

How the mind got into the brain

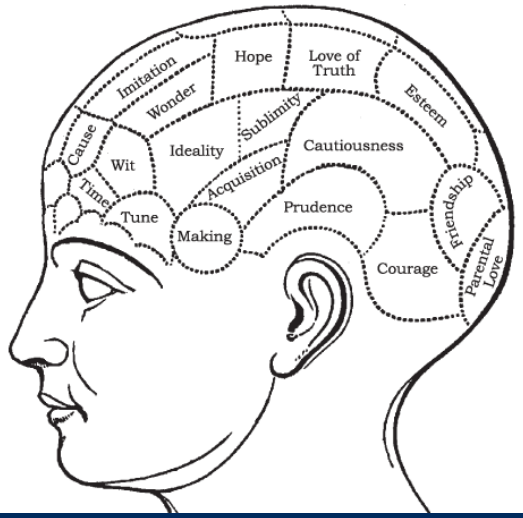
- Thomas Willis (17th century)
  - Father of clinical neurology.
  - Linked brain damage with cognitive dysfunction
    - Followed patients for many years and then did postmortum dissections.

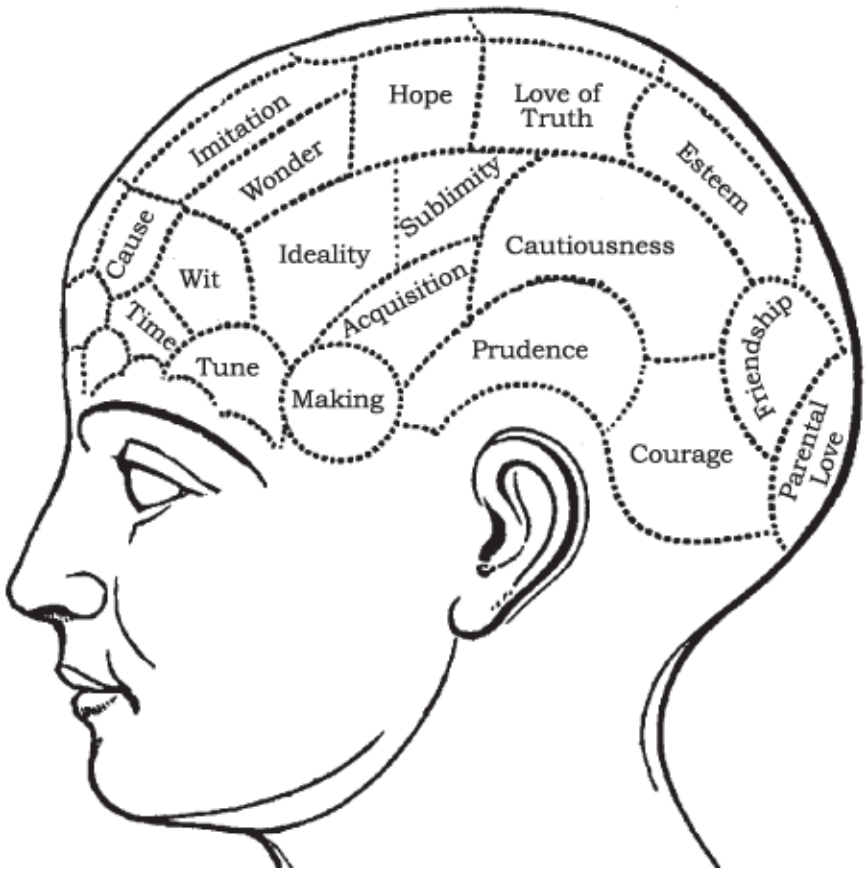


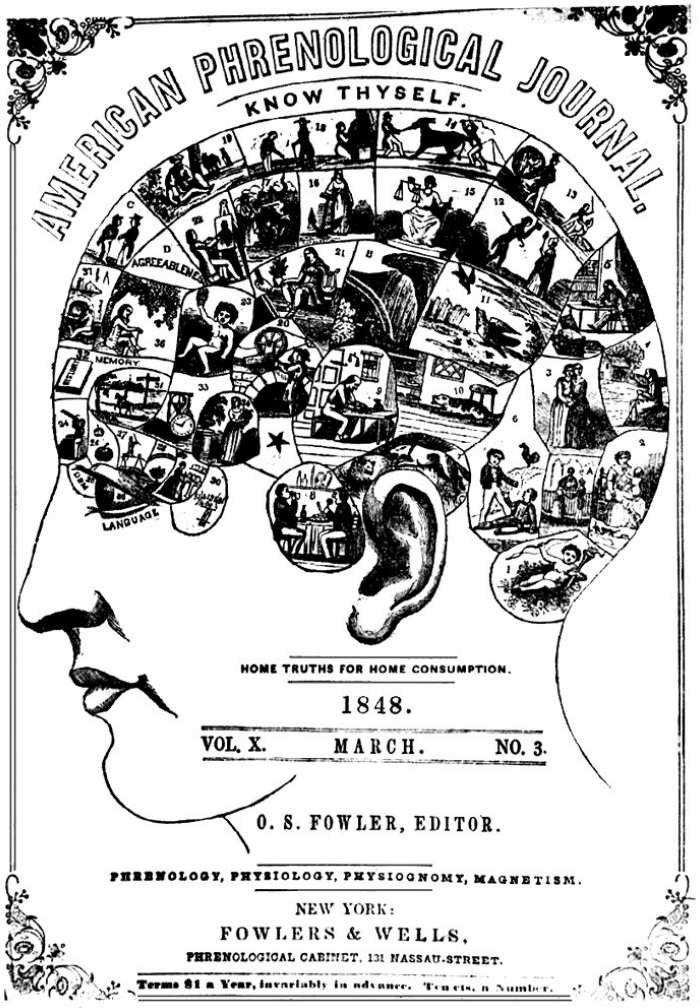
The illustration shows a normal brain (left) and a brain from a case of congenital mental retardation(right).

Phrenology (early 19th century)

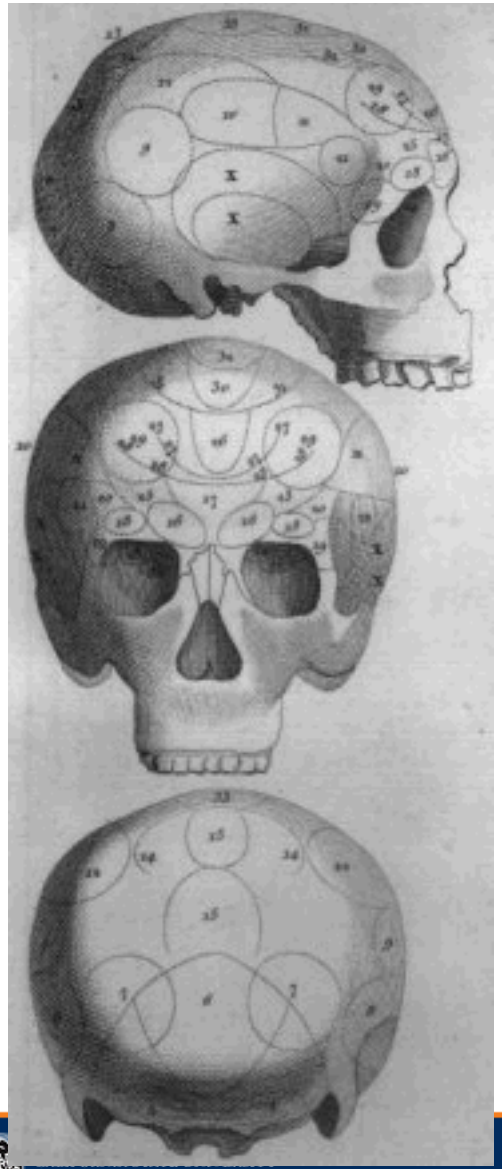
- Led by Franz Gall (1758-1828)
- "Localizationist" view
  - *Cognitive* functions to specific brain regions
  - Idea:
    - Using a mental function caused corresponding brain region to grow bigger,
    - Which created bumps on skull




Imitation
Hope
Love of Truth
Wonder
Esteem
Sublimity
Cause
Ideality
Cautiousness
Wit
Acquisition
Time
Tune
Prudence
Making
friendship
Courage
Parental Love


AMERICAN PHRENOLOGICAL JOURNAL.
KNOW THYSELF.
HOME TRUTHS FOR HOME CONSUMPTION.
1848.
VOL. X. MARCH. NO. 3.
O. S. FOWLER, EDITOR.
PHRENOLOGY, PHYSIOLOGY, PHYSIOGNOMY, MAGNETISM.
NEW YORK:
FOWLERS & WELLS,
PHRENOLOGICAL CABINET, 131 NASSAU-STREET.

Phrenology



The good…

Brought about the idea that different mental functions are localized to discrete brain regions

the bad…

Cannot determine cognition by bumps on the skull (if only it were that easy)

and the ugly

Good mother

Bad mother

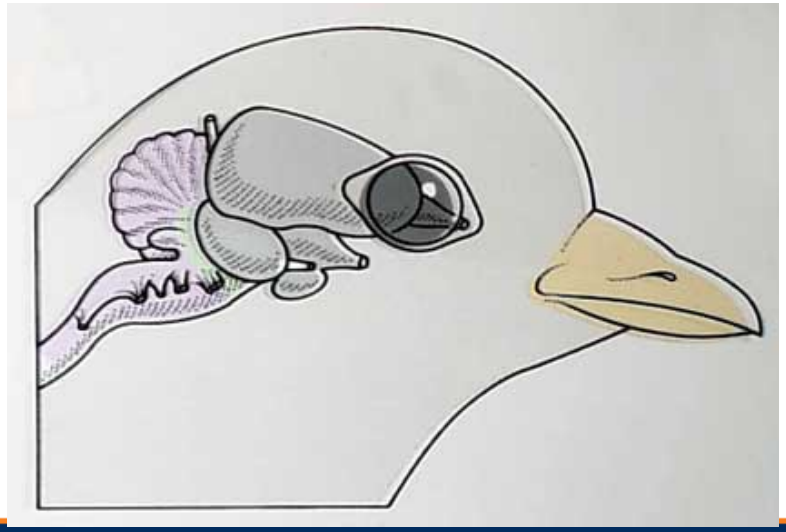
Or who we should marry

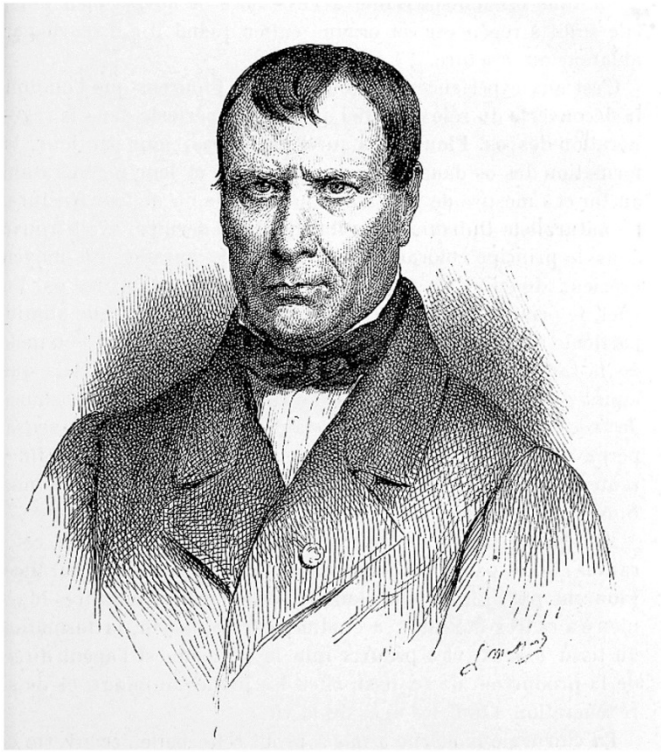

Then...
Bumps and grooves are used to infer complex behaviors.


Now...
Bumps and grooves are used to infer complex behaviors.

Localizationism vs Holism

- Aggregate field theory – holism
  - *Whole brain participates in each behavior.*
    - Birds with brain lesions recover no matter where lesion was
    - Lesions did not produce specific deficits.

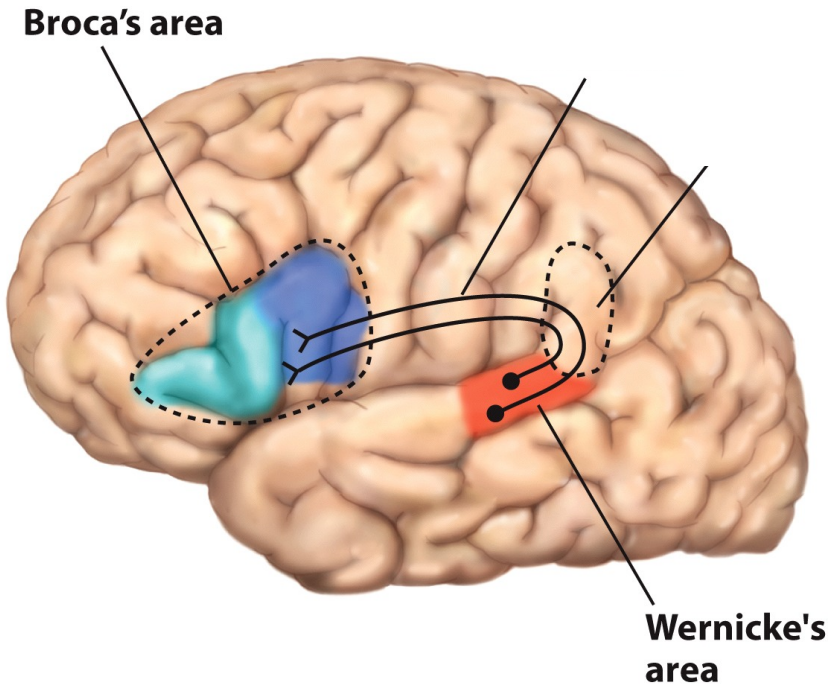




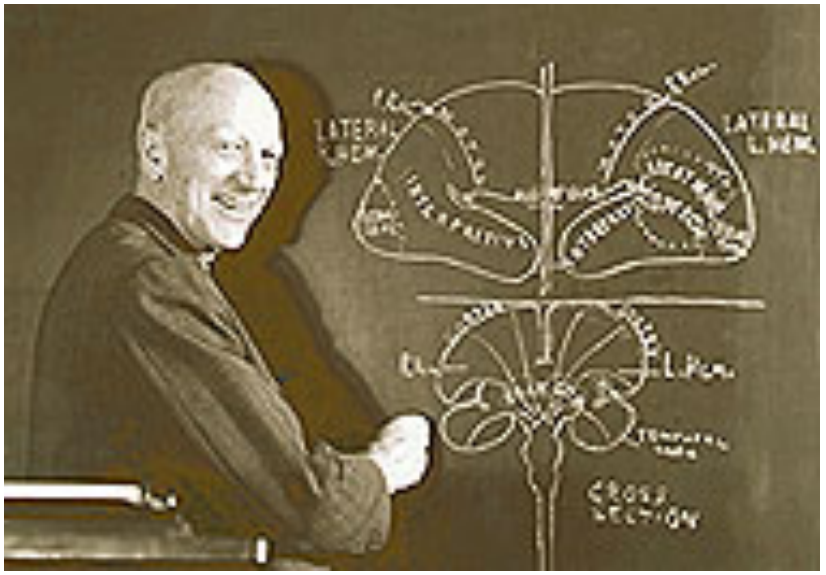
Pierre Flourens

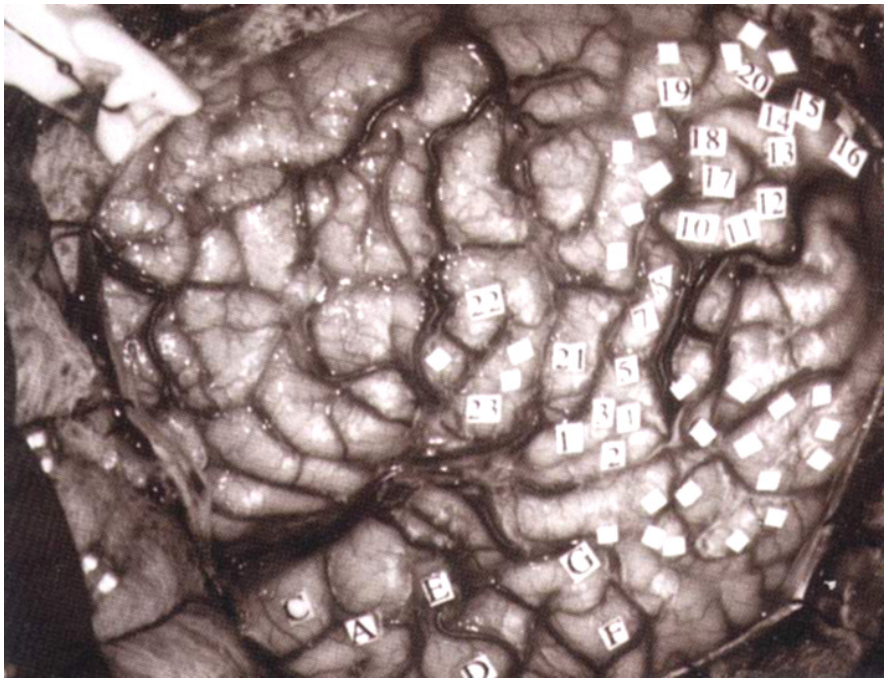
Localizationism vs Holism (1860s)

- 1861: Paul Broca's patient "Tan"
  - Inability to generate speech *(Broca's aphasia)*
  - Post-mortem autopsy found left anterior region lesion
- 1874: Carl Wernicke
  - Comprehension loss *(Wernicke's aphasia)*
  - Post-mortem autopsy found posterior region lesion



Wilder Penfield
Canadian neurosurgeon
(1896-1976)





- 1950s: *stimulated* brain tissue to find source of epileptic seizures
- stimulating different parts of brain elicited different movements, sensations, memories, etc.
- developed map of motor cortex "motor homunculus"

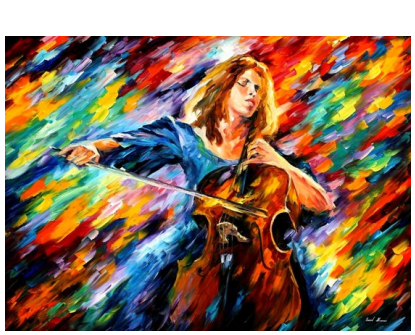
Localizationism vs Holism: Who wins?

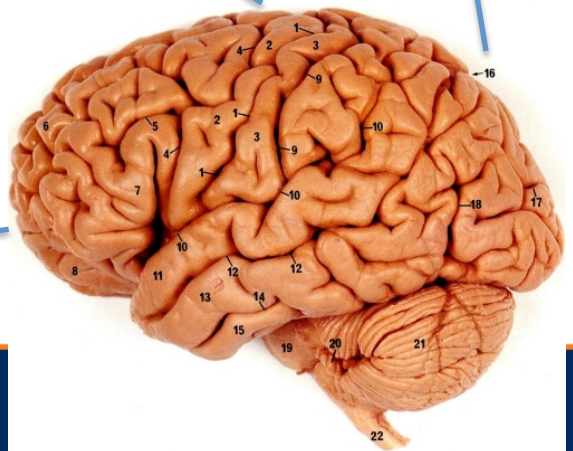
- Both were partially right

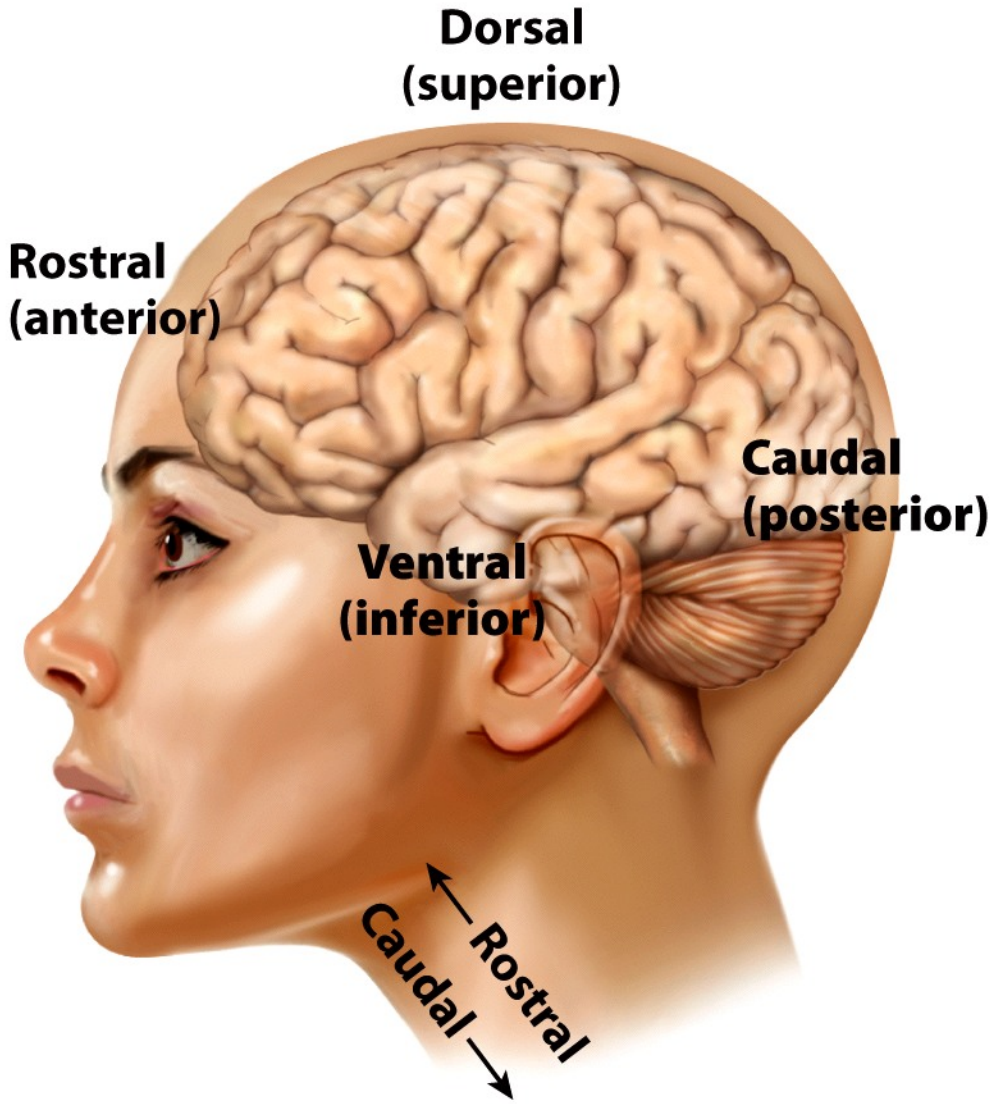
- Specific processes can be localized to single brain regions
- BUT complex functions are carried out by many brains regions acting in concert
- Debate continues in almost every domain of study in cognitive neuroscience.

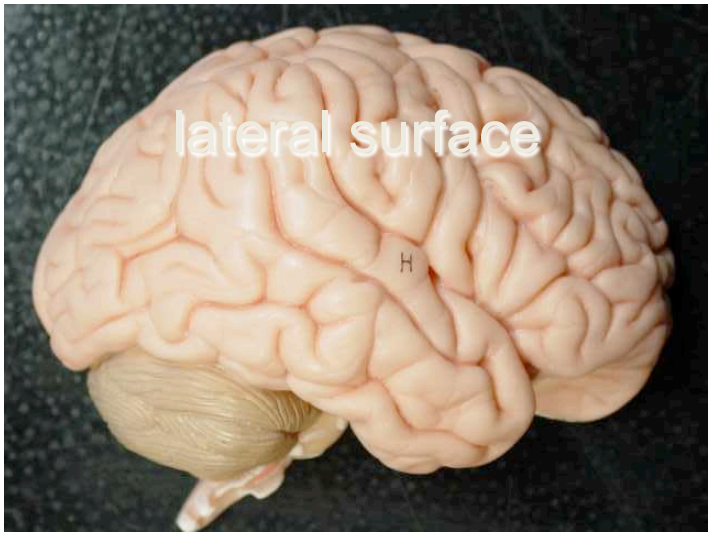
Next two sections

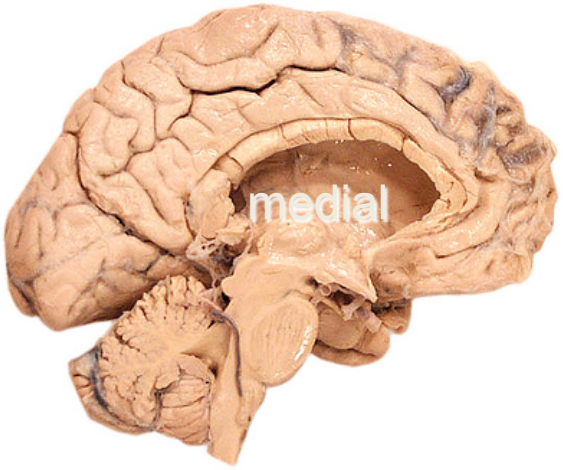
Brief overview of the findings and tools to investigate Marr's physical level



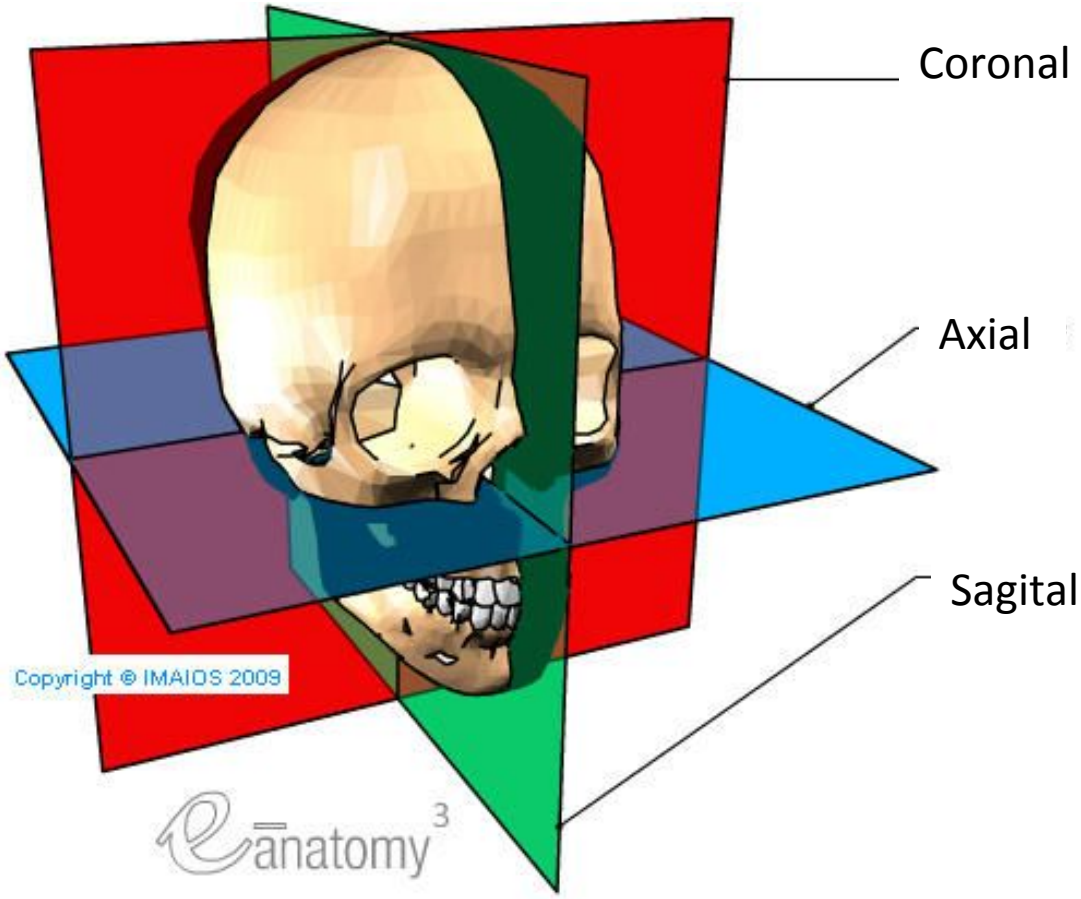



Dorsal
(superior)
Rostral
(anterior)
Caudal
(posterior)
Ventral
(inferior)
Rostral
Caudal



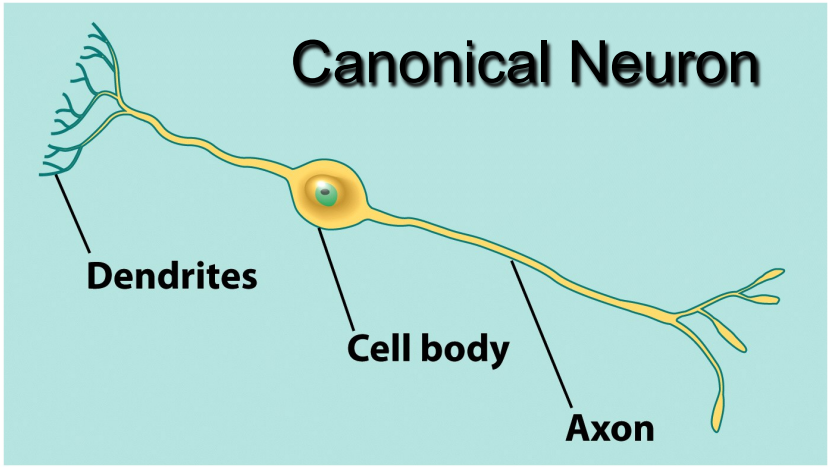


- Lateral: toward the outside.
- Medial: toward the inside (middle).



- Sagittal, coronal, and axial planes.

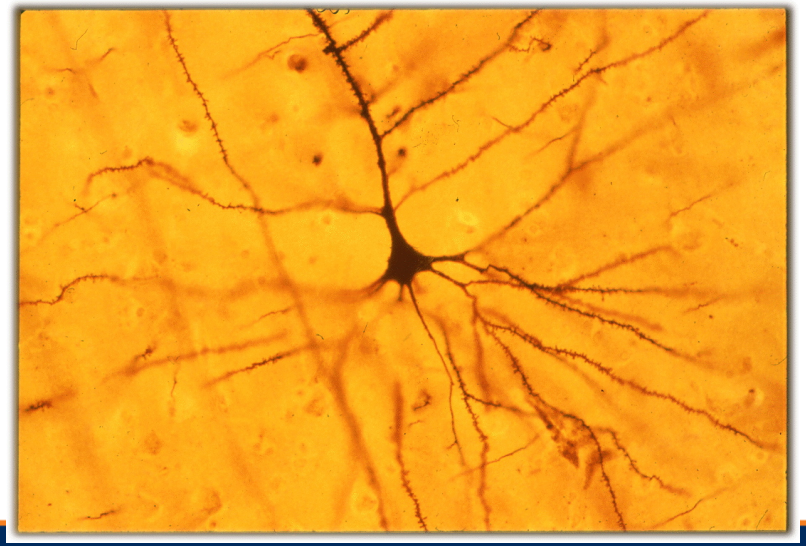
Micro-neuroanatomy: Cell staining



Stain cell bodies and processes with *Golgi Stain*, i.e.,cytoarchitectonics

Structure

1. Dendrites: input
2. Cell body (soma):
3. Axon: output



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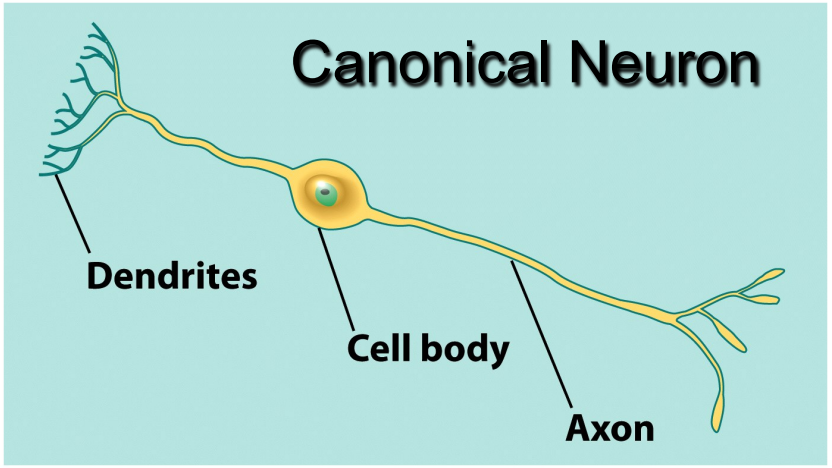

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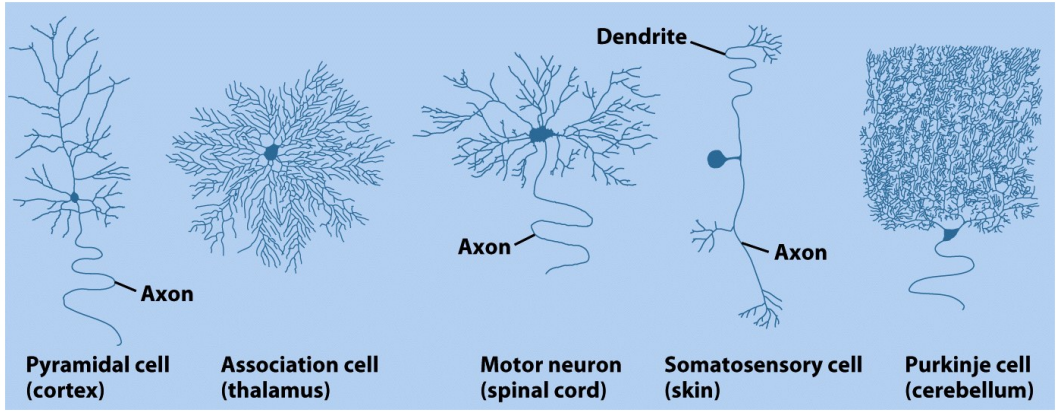
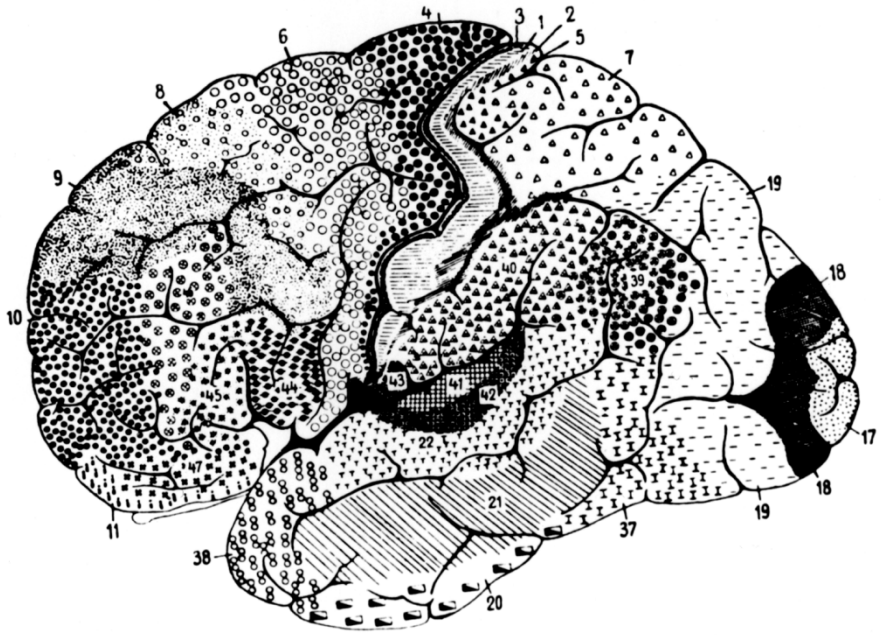
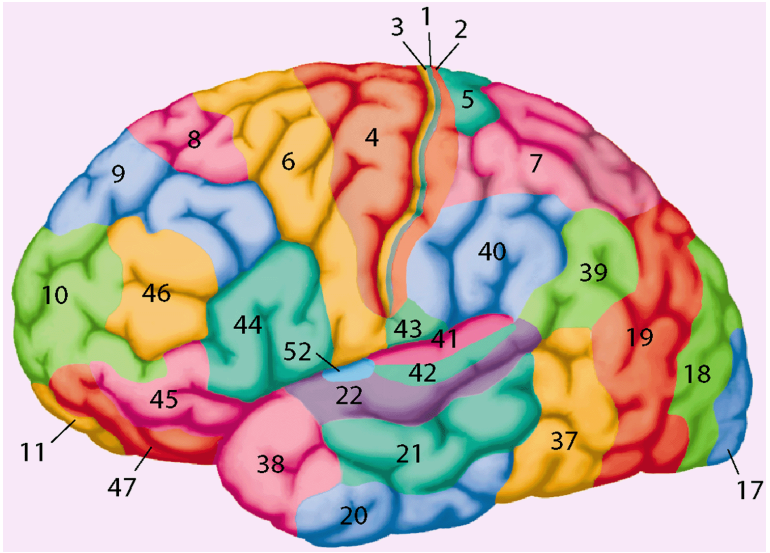
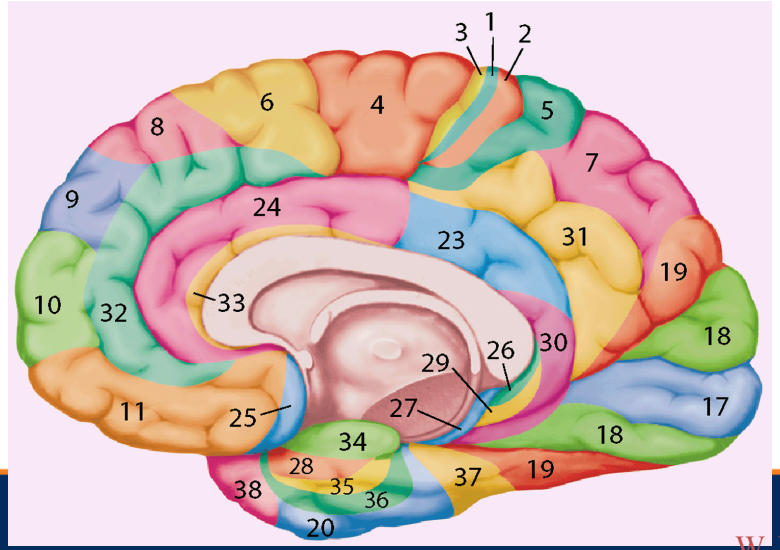


- 100 billion neurons
- About 10,000 connections with other neurons

Brodmann's areas



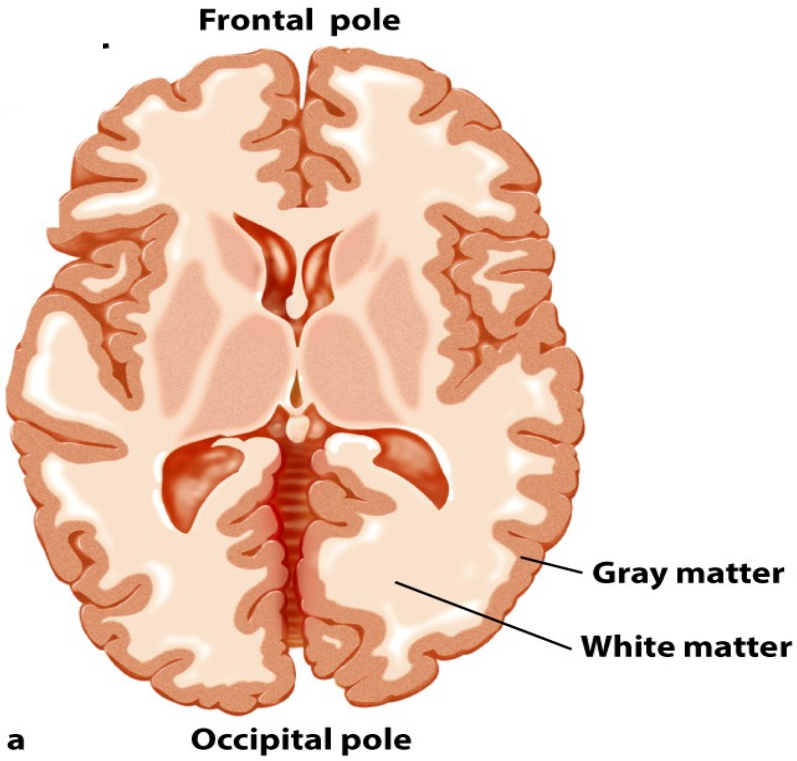


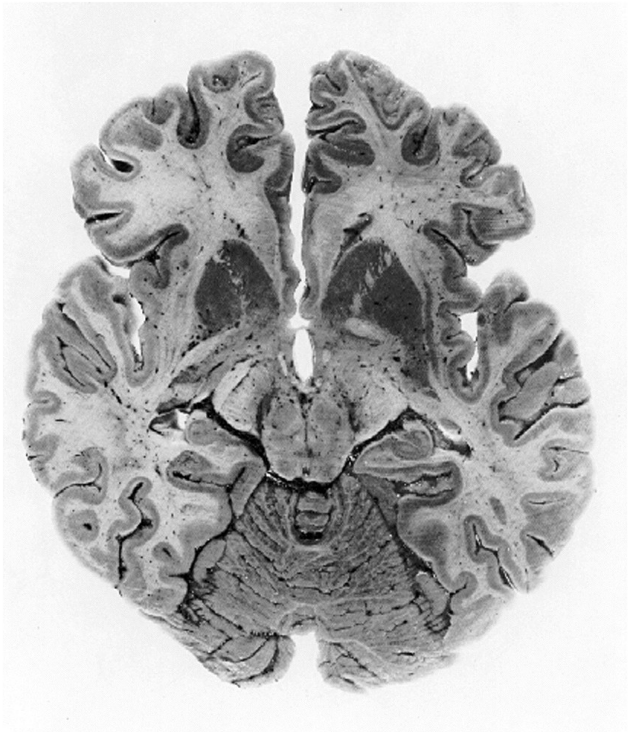


- Broadman's area based on different cell types (cytoarchitectonics) in postmortem brain.

Gross Anatomy

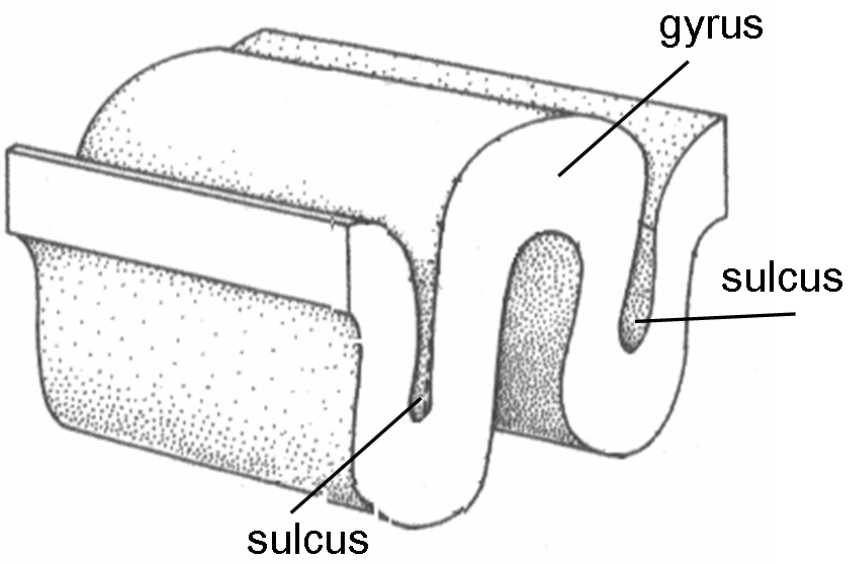
- Two types of tissue: gray and white matter.
  - Grey – cell bodies (soma & dendrites)
  - White - axons



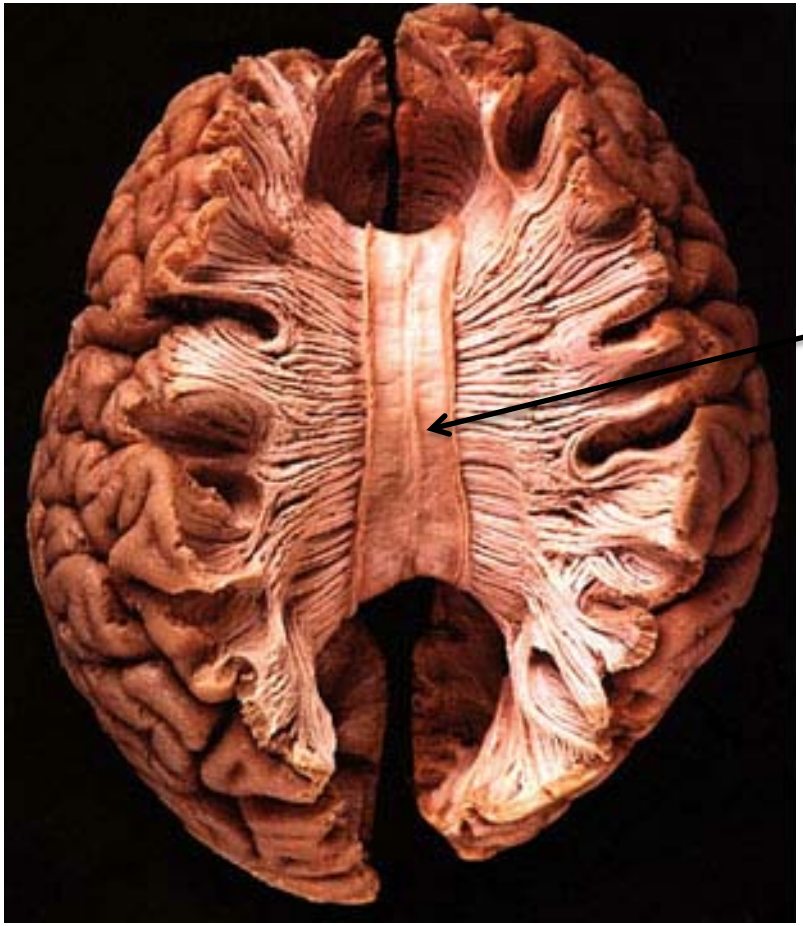


Gross Anatomy

- Peaks and troughs
- Gyri (protrusion) and sulci (invagination).



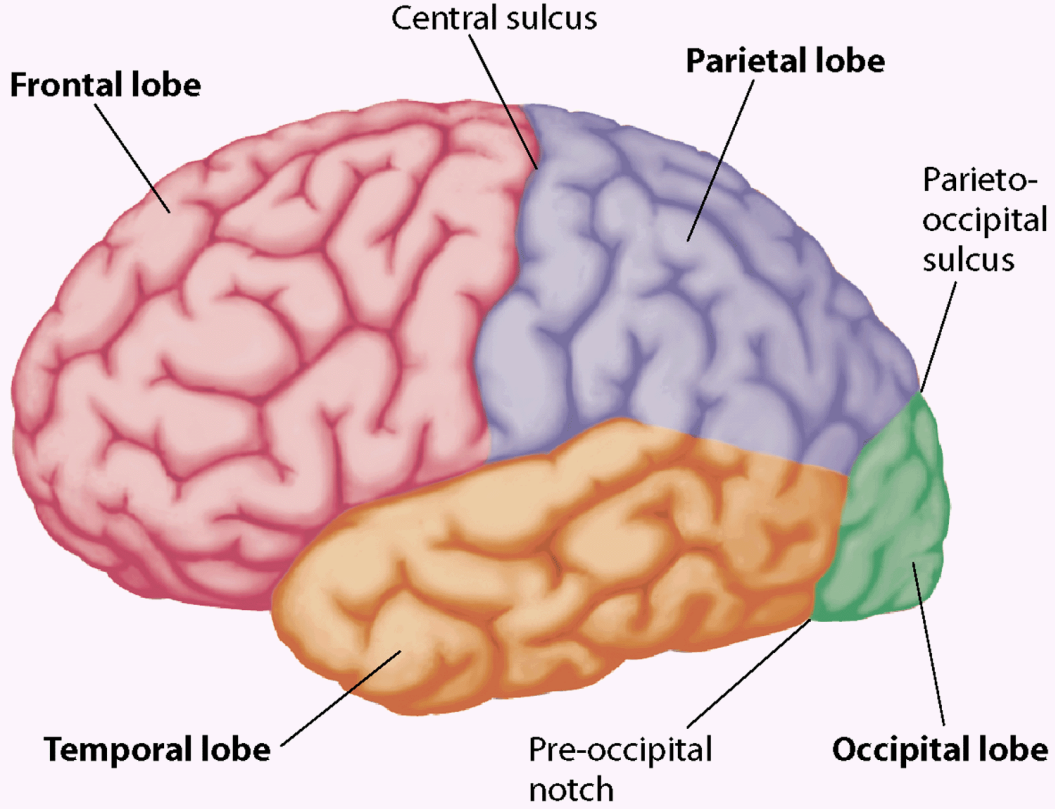
Gross Anatomy



- Brain has left and right hemispheres.
- Connections between lobes via corpus callosum.

Gross Anatomy: Lobes

Dorsal/ superior

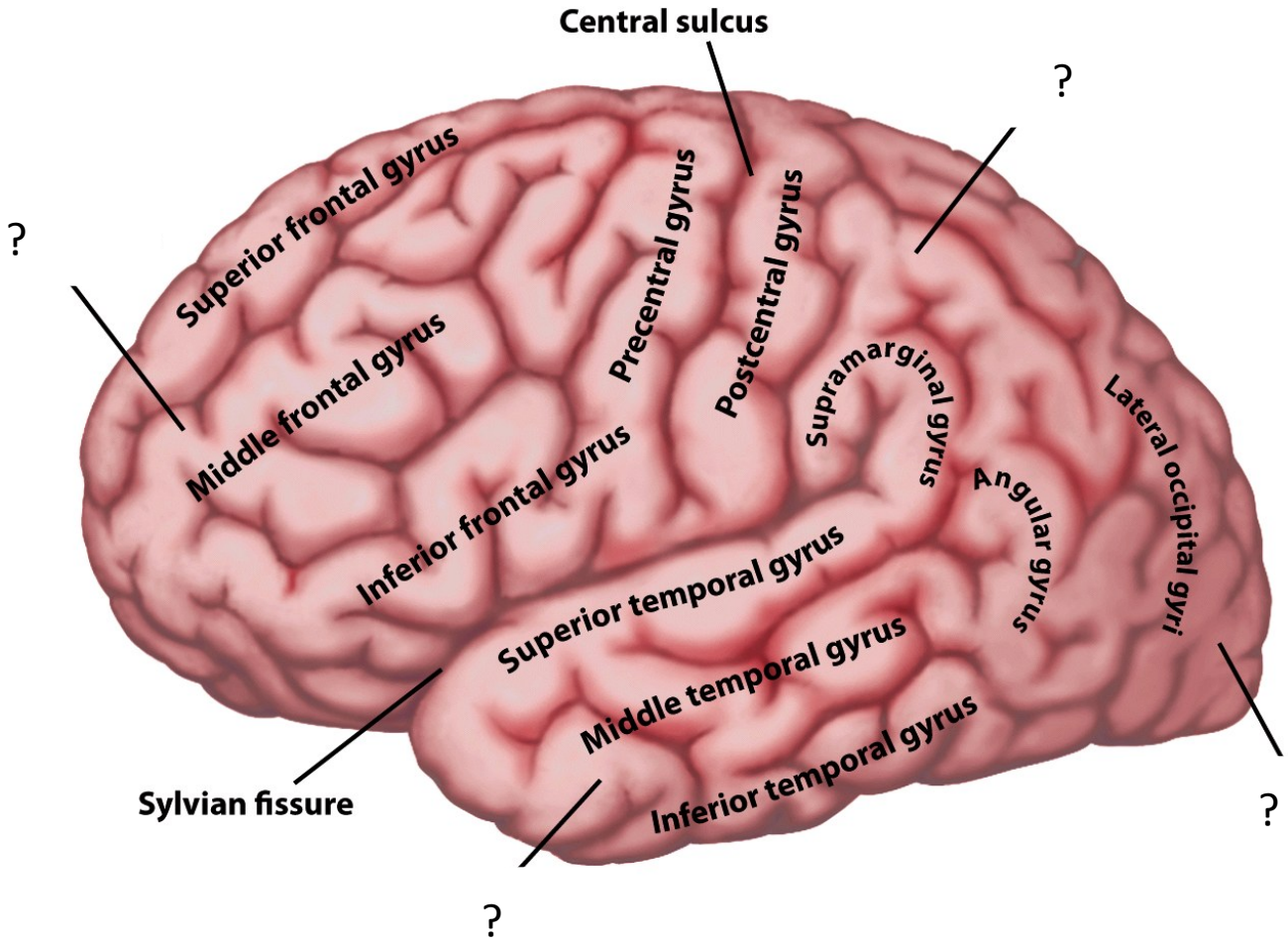


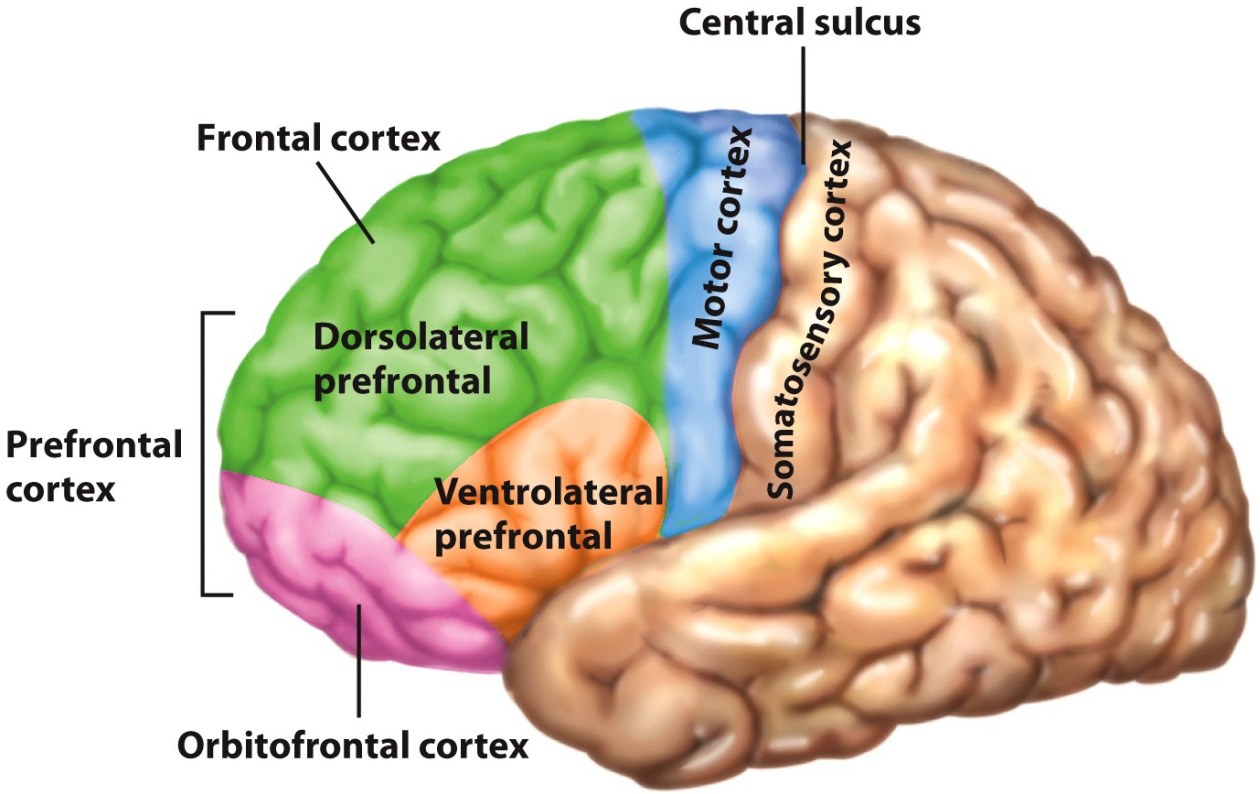
Anterior/ rostral

Posterior/ caudal

Ventral/ inferior

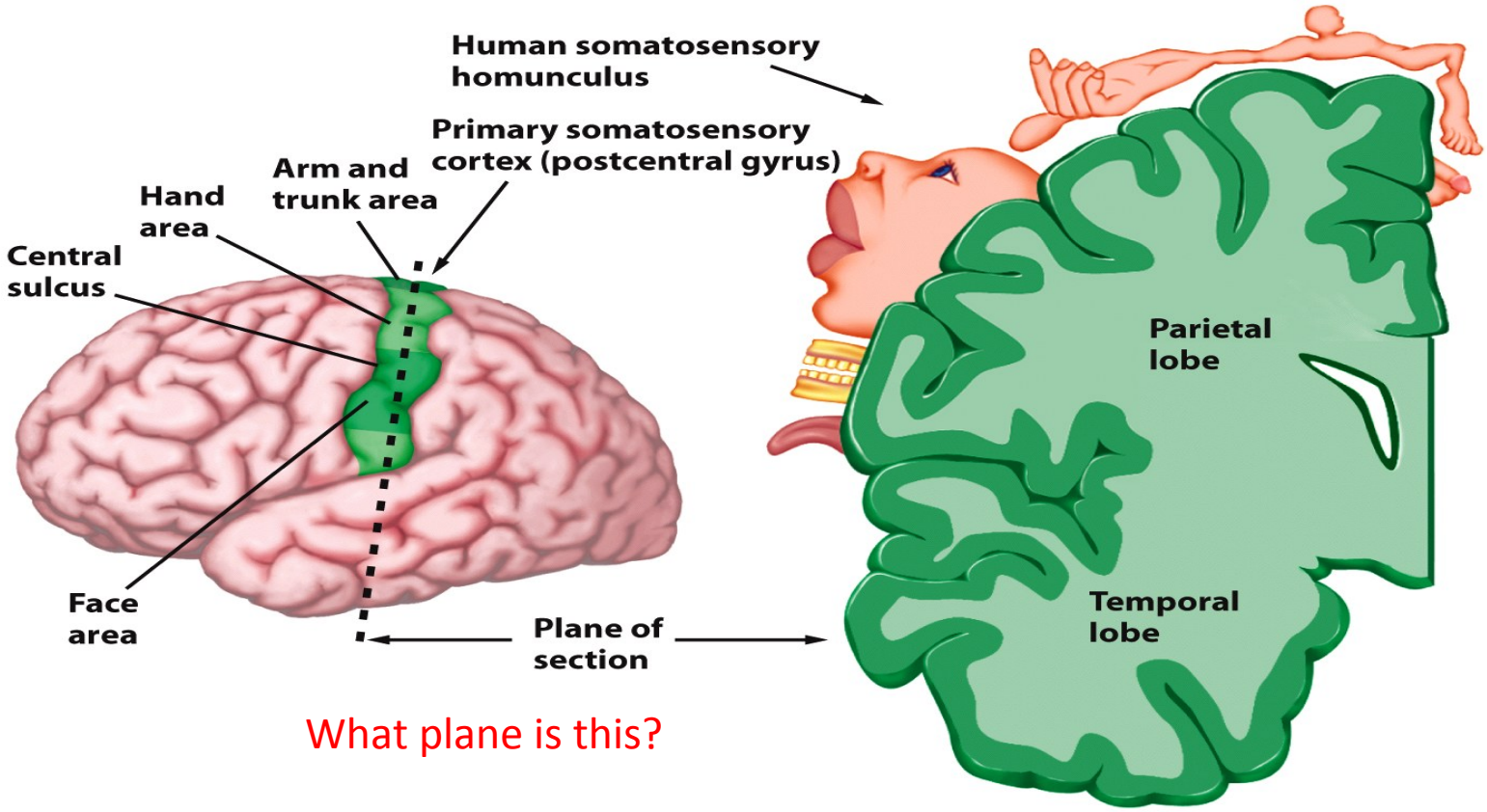
Gyri and Sulci on the lateral surface





- Functional subdivisons based on
  - loss of function from lesions
  - manipulation of function from stimulation.

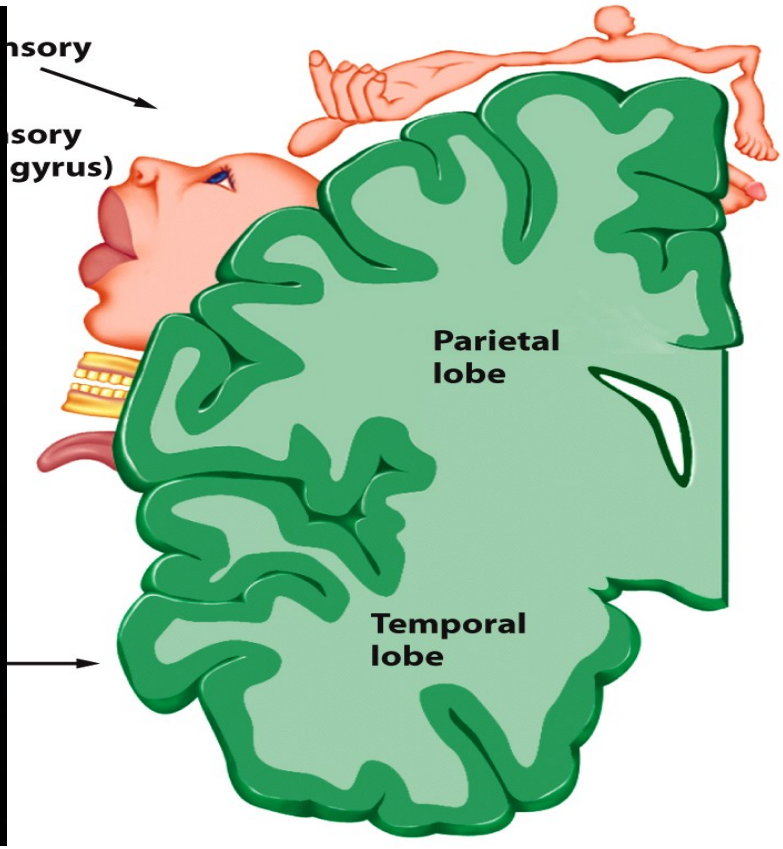
Cortical maps



What plane is this?

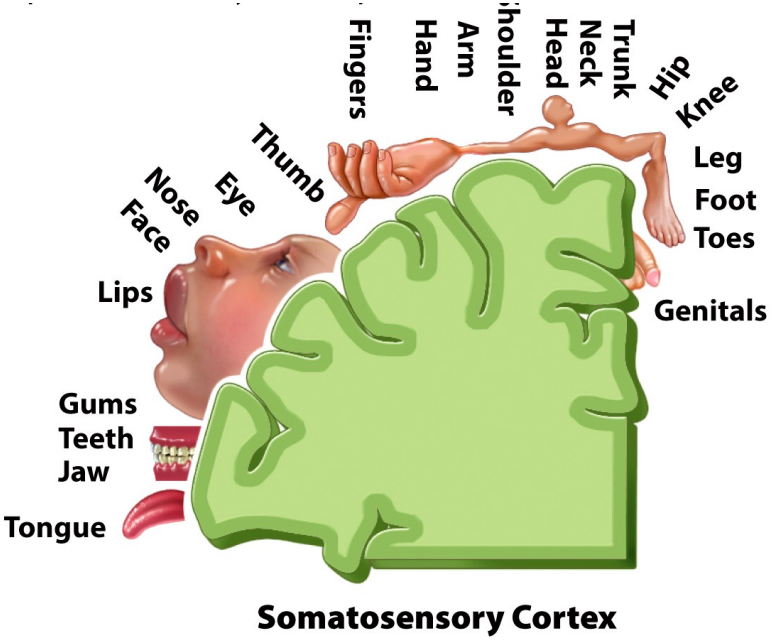
- Our representation of the somatosensory world is mapped onto our brains!
- Topographic correspondence between cortical regions & body surface

Cortical maps



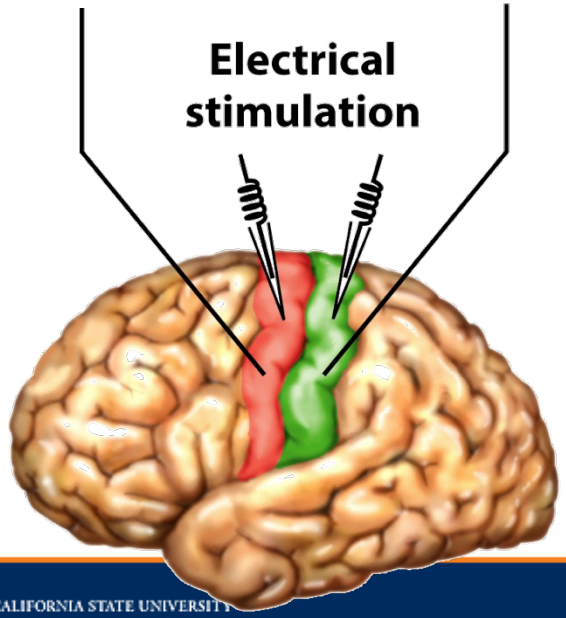
- Amount of cortex used is associated with how much you use that body part
  - Not the size of the body part

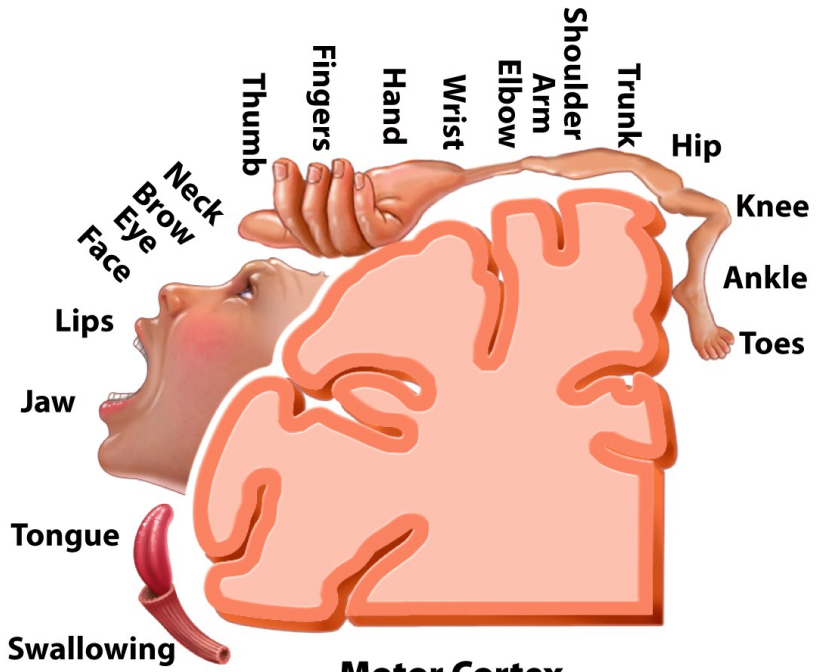
- This topographic map also exists in motor cortex in similar way



Somatosensory Cortex

Somatosensory cortex: somatic sensation

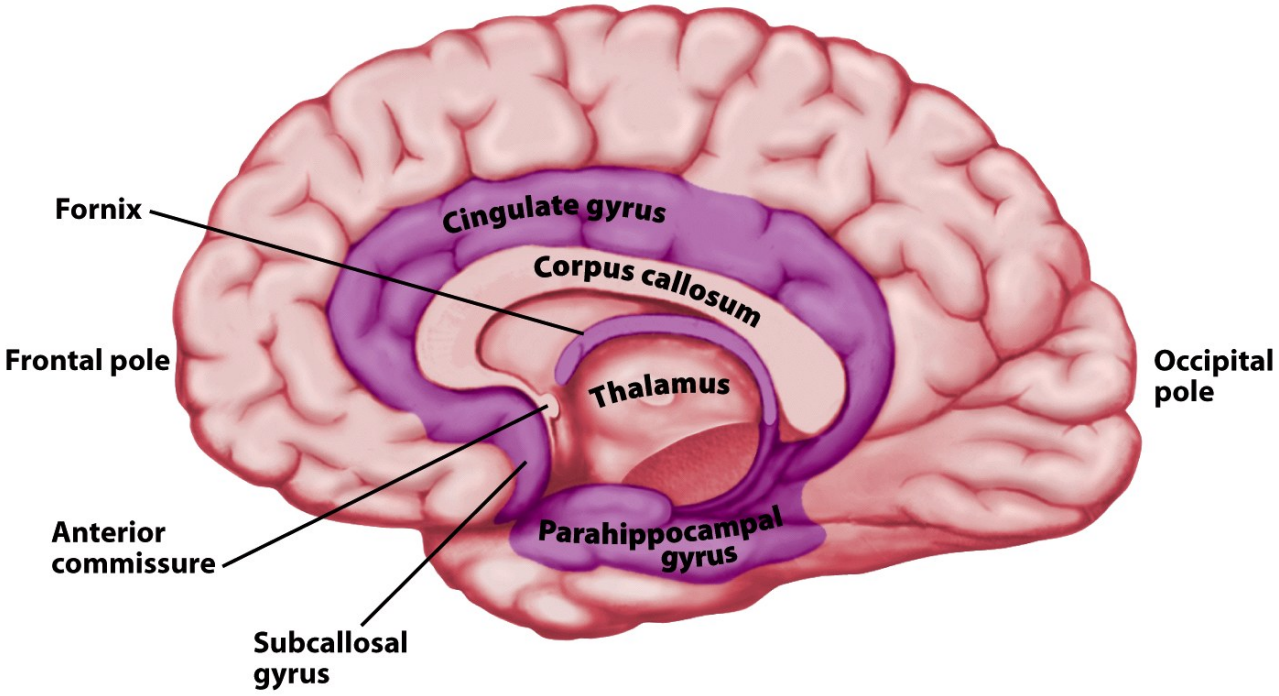




Motor Cortex

Limbic system

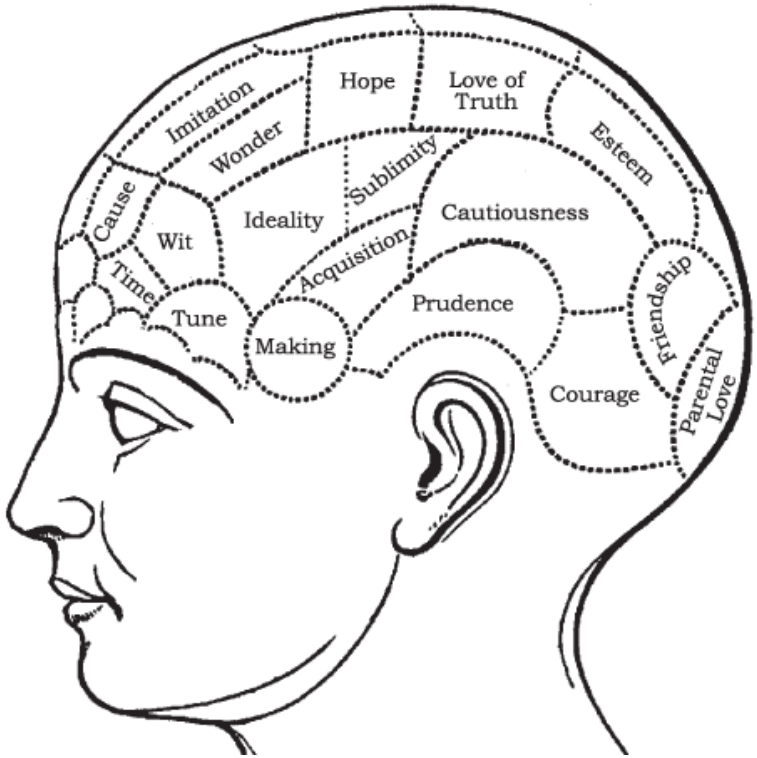
- Composed of hippocampus, hypothalamus, parts of thalamus, amygdala, and parts of basal ganglia.
- Limbic system: emotion and behavior, learning, memory

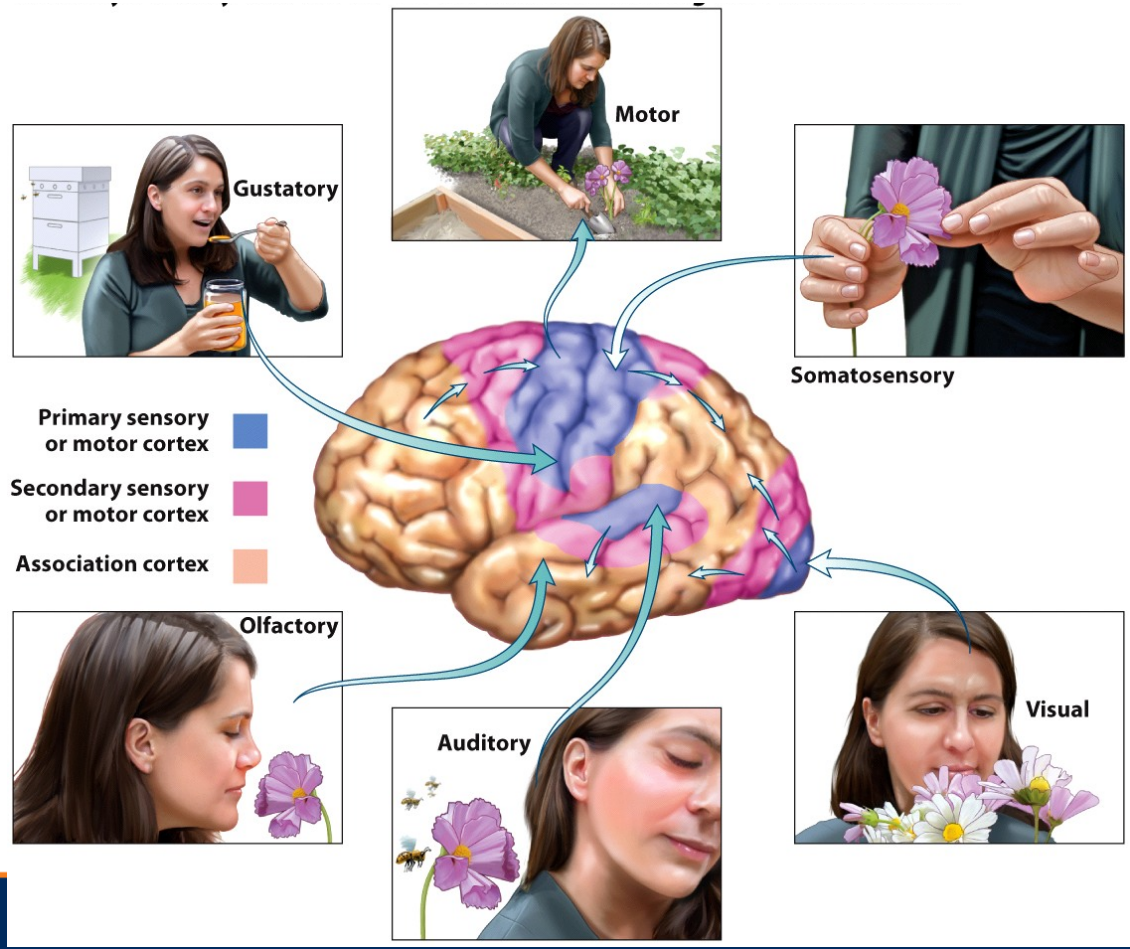


From Phrenology to CogNeuro

early 19th century

~Last 30 years





Review

- Coordinates
  - Dorsal/ventral, anterior/posterior, superior/inferior, rostral/caudal
  - Coronal, axial, sagittal
  - Lateral, medial
- Neuron structures
  - Soma, axon, dendrites
- Grey matter/white matter
- Corpus collasum
- Lobes – FPOT
- Gyri – if you know coordinates, you can name gyri
- Functional subdivisions
  - 3 PFC areas
  - Precentral and postcentral gyri – cortical maps
- Limbic system – where is it, what structures are involved